Method for controlling a data transmission in a radio communication system with a hierarchical network architecture

The present invention relates to a method for controlling a transmission of data in a radio communication system with a hierarchical network architecture and user equipment. The entire radio communication system thus comprises two basic components. On one side user equipment is provided which is the start point or end point of data connections in the radio communication system. The user equipment can be embodied as stationary, fixed user equipment or also as mobile user equipment. On the other side a network architecture is provided made up of hierarchically structured network devices which exchange data with the user equipment via a radio interface. The devices of the hierarchical network architecture can likewise be embodied as stationary, fixed devices or also as mobile devices. Radio communication systems can even be provided in which devices can act as both user equipment and as devices of the hierarchical network architecture, for example in the case of a decentralized ad-hoc network.

This type of hierarchical network architecture means that the network architecture features devices of different hierarchy levels, with devices of the higher hierarchy being assigned certain control and checking tasks over devices of the lower hierarchy. In such radio communication systems all types of data transmission can basically be provided, i.e. signaling data or payload data such as voice data, multimedia data or similar, for example the transmission of packet data.

Radio communication systems with hierarchical network architecture are sufficiently known from the prior art. Thus US 2002/0021692 for

example describes a mobile telecommunications system designed for packet data transmission. This patent especially describes a method for High Data Rate (HDR) packet data transmission as will be standardized within the framework of the 3rd Generation Partnership Project 2 Organization (3GPP2). In particular this describes the control of packet data transmission between an Access Network (AN) and an Access Terminal (AT) which occurs as a function of the signaling on a Reverse Link between the Access Terminal (AT) and the Access Network (AN), that is as a function of the signaling on the air interface. Within the framework of this document the intention is to specifically optimize the load on the Reverse Link, i.e. between a hierarchical network architecture and user equipment (terminal).

The object of the present invention is thus to provide an option for controlling a transmission of data in a radio communication system with a hierarchical network architecture and user equipment. This object is achieved by the features of the independent patent claims. Developments of the invention can be taken from the dependent patent claims.

The invention comprises a method for controlling a transmission of data in a radio communication system with a hierarchical network architecture and user equipment. In accordance with the invention there is now provision for a device of a lower hierarchy of the hierarchical network architecture to transfer cell load reporting signals to a device of a higher hierarchy of the hierarchical network architecture and for the device of the higher hierarchy to control transmission capacities of the device in the lower hierarchy based on the cell load reporting. In this way the device in the higher hierarchy receives information which is based on the data load present at a corresponding device in the lower hierarchy. The

device of the higher hierarchy can then adapt the checking and/or control of the lower hierarchy device specifically to control of the transmission capacities of lower hierarchy devices based on this information. This method is thus especially advantageous for those radio communication systems in which the standard signaling between the different hierarchy levels is designed so that the device of the higher hierarchy has only restricted knowledge or no knowledge about operational relationships to devices of lower hierarchies, specifically about such operating relationships which have a particular relationship with the data load at the corresponding device of the lower hierarchy.

A further development of the present invention provides for specific information about the load states for the area of the radio communication system served by the device of the lower hierarchy to be transferred as cell load reporting. Thus in this special case the information transmitted is that which gives direct details of the load states at the device in the lower hierarchy. This gives the device in the higher hierarchy direct knowledge about these load states at the device in the lower hierarchy.

In particular provision can be made for load values averaged over time for defined parameters to be provided as information about the load states and/or signaling types of the radio communication system for radio data connections between a device of the lowest hierarchy and user equipment. Such defined operating parameters and/or signaling types can for example be the average utilization of physical transmission capacities, the average use of specific types of modulation, the average number of transmissions of selected signaling, the average occupancy times of data buffers etc. The

averaging over time ensures that precisely for cases of load values which change significantly over time, a load value determined as just a one-off and short-term value does not affect the further execution sequences in the radio communication system.

The cell load reporting can be used to optimize a wide diversity of execution sequences within the hierarchical radio communication system. There can also be provision for example for individual devices of the same hierarchy to exchange information with each other about the corresponding cell load reporting, so devices of higher hierarchies also receive load-based information from devices of lower hierarchies not directly assigned to them.

The load-based signaling especially provides devices of the higher hierarchy with a knowledge of the load situation and load distribution at assigned devices of the lower hierarchy. For example an optimization or equalization of the load situation can then be initiated by a device at a higher hierarchy at individual assigned devices of the lower hierarchy. Thus provision can be made in particular for an assignment of user equipment to particular devices of the lowest hierarchy to be checked on the basis of cell load reporting. Since in accordance with the invention a device of a higher hierarchy has an overview of the utilization situation at the assigned devices of the lower hierarchy, the device of the higher hierarchy at least makes proposals for a changed assignment of terminals to specific devices of the lower hierarchy or the device of the higher hierarchy can directly initiate a changed assignment of terminals to specific devices of the lower hierarchy.

A specific further development of the method just described can be implemented when a cellular radio communication system is provided

as the radio communication system. A check can then be made on the basis of load-based signaling of a handover option for at least one terminal of a first cell of the radio network into a second cell of the radio communication system. The methods for subsequent execution of such a handover for terminals in a cellular radio communication system are basically sufficiently well known from the prior art and need not be described in further detail here.

The cell load reporting can be transmitted from the lower hierarchy device to the higher hierarchy device as a function of various events. Thus provision can be made for example for the cell load reporting to be transmitted depending on specific timing events. Either discrete, defined points in time can be defined as time events or the sequence of defined time intervals can be defined as the time event. Provision can be made as a special case for the cell load reporting to be transmitted periodically, that is after consecutive identical time intervals have elapsed in each case.

As an alternative there can also be provision for the cell load reporting to be transmitted as a function of specific operating events of the radio communication system. Thus for example the cell load reporting can be undertaken as a function of defined load states for the area of the radio communication system served in the lower hierarchy. Basically any other operating events can also be defined which initiate a cell load reporting. Thus the cell load reporting can for example also be linked to specific signaling within the radio communication system.

As a special case of said method provision can be made for the cell load reporting to be undertaken depending on defined threshold values for the load states. Cell load reporting can therefore be undertaken if predefined threshold values are exceeded or undershot for defined load states. The operating parameters already mentioned and/or signaling types of the radio communication system can be used as defined load states, as can the utilization of physical transmission capacities, the use of particular types of modulation etc.

The method in accordance with the invention can basically be applied to all suitable types of radio communication system which feature a hierarchically-structured network architecture. The method can be used especially advantageously for control of a transmission of data packets in a packet data transmission system.

A further object of the present invention is a radio communication system with a hierarchical network architecture with devices for controlling a data transmission and with user equipment. Here the hierarchical network architecture features lower-hierarchy devices and at least one higher-hierarchy device. There is provision according to the present invention for at least one lower-hierarchy device to be embodied for transmission of cell load reporting to a higher-hierarchy device and for the higher-hierarchy device to be embodied for control of transmission capacities of the lower-hierarchy devices on the basis of the cell load reporting.

The advantages of this inventive radio communication system are obtained in a similar manner to that of the inventive method already described. The individual devices of the inventive radio communication system can also be developed and adapted to make them

suitable for executing individual steps or all steps of the above-mentioned inventive method.

Basically any suitable type of radio communication system can be provided as the radio communication system. Preferably the radio communication system can be embodied as a packet data transmission system.

A specific exemplary embodiment of the present invention is explained below, using a radio communication system for packet data transmission as an example.

The figure shows:

FIG.1 a schematic diagram of a radio communication system for packet data transmission

FIG 1 shows a block schematic of the most important components of a radio communication system for packet data transmission. The 3GPP organization already mentioned at the start basically specifies methods designed to allow efficient packet data transmission to user equipment. One component of the methods is for example an adaptive modulation and a time-based scheduling of physical resources in a base station (also referred to within the framework of a packet data transmission as NodeB, cf. FIG. 1), that is in a device of the lowest hierarchy of a radio communication system for packet data transmission. The methods are also referred to as „High Speed Downlink Packet Access (HSDPA)„ where downlink indicates the transmission of packet data in the downstream direction from a base station to a UE (User Equipment).

There is provision within the framework of 3GPP for expanding the area of responsibility and the task area of a base station NodeB in comparison to normal radio communication systems. In this case the base stations NodeB are given the sole responsibility of controlling the transmission capacities, i.e. physical resources assigned to them, for a packet data transmission to user equipment UE on common channels. In this case there can also be signaling between user equipment UE and a base station NodeB for the case of an errored transmission of packet data on the basis of which the base station NodeB undertakes a retransmission of the incorrectly transmitted data packet. To this end data packets are requested by the base stations NodeB from hierarchically higher devices in the network architecture and stored in first buffers, known as scheduling queues until the transmission of the data packets over the air interface to the user equipment UE is completed. Data packets sent are stored in second data memories, known as retransmission buffers, until such time as the receipt of the data packet from the corresponding user equipment has been positively acknowledged or until a defined send time has been exceeded.

A device of a higher hierarchy of the network architecture of the radio communication system is also shown in FIG. 1, namely as a network node embodied as a switching and control device, a so-called Controlling Radio Network Controller CRNC. This network node CRNC in particular basically has control of transmission capacities - that is over physical resources - of the base stations NodeB 1, NodeB 2 which are subordinate to it in the hierarchy. In a radio communication system there is provision as a rule for a plurality of such network nodes CRNC which may be subordinate to further devices with higher hierarchies in their turn. Thus the network nodes CRNC and the base stations NodeB 1, NodeB 2 connected to them in the data

system form a hierarchical network architecture of a radio communication system.

The radio communication system is embodied in the case of FIG. 1 as a cellular radio communication system. The base station NodeB 1 serves a cell A and a cell B, the base station NodeB 2 serves a cell C and a cell D. In the example according to Figure 1 there is exactly one user terminal UE1 in the cell B, two terminals UE2, UE3 are in the cell C.

For the methods proposed in 3GPP the base stations NodeB 1, NodeB 2 are given the functionality to plan and suitably assign the physical resources for the transmission of data packets to user equipment UE1, UE2, UE3. This planning and assignment of resources can be undertaken by the base stations on the basis of values for the transmission quality or Quality of Service (QoS) for specific current applications in the cell, on the basis of the data rates at the radio interface and/or on the basis of the interference and load situation in the relevant radio cell at that moment. Thus certain control functions are transferred to the base stations which would usually be fulfilled in the centralized network architecture (UTRAN) by the higher ranking network-nodes CRNC. This leads to the problem that the hierarchically higher ranking network node CRNC has only conditional information or no information at all about the current load situation at the base stations NodeB 1, NodeB 2 assigned to it. Thus a network node CRNC could not effectively execute certain checking and control functions which would also be sensible in a hierarchical network architecture, for example admission control and load control.

The above-mentioned problems can, as just shown, occur in a radio communication system for packet data transmission operating in accordance with the HSDPA principle. Basically however comparable

considerations can also apply to other hierarchical radio communication systems, as has already been shown at the start of this document. When the HSPDA principle is used in a radio communication system for packet data transmission there is provision on the one hand for the CRNC, when a radio connection to user equipment is established, to release physical resources at the base stations NodeB administered by it (resource allocation for HSDPA, abbreviated in FIG. 1 to RA HSDPA). Without the measures of the invention however the CRNC would not obtain any knowledge about the actual use of the physical resources by the base stations NodeB since a scheduling of the data packets to be transmitted is undertaken in the base stations NodeB. Without the measures of the invention the CRNC would thus have no control over the actual use of the allocated resources in the cells of the radio communication systems subordinate to it.

This is where the invention can help. As shown in FIG 1, the current load state in the relevant cell A, B, C, D of the base stations NodeB 1, NodeB 2 is reported to the CRNC (Cell Load Reporting CLR for cell A, B or for cell C, D). The load states in the relevant base stations NodeB or in at the relevant cells of the last transmitted directly as cell load reporting. This ensures that even with the use of HSDPA - or basically with comparable problems in hierarchical radio communication systems - the CRNC as a device of a higher hierarchy can continue to exercise sufficient checking and control functions for NodeB devices subordinate to it of the lower hierarchy. Such checking and control functions can for example be an admission control (AC) or a load control (LC).

The cell load reporting CLR of the load states for the cells A, B, C, D can for example be undertaken periodically or event-driven,

e.g. if a specific threshold value is exceeded or undershot. The current load states for the cells A, B, C, D can be transmitted as values which represent average values over time for the average usage of signaling or can also represent physical resources which have been assigned for HSDPA. Thus for example the average utilization of the number of code channels, the average use of specific types of modulation, the average occupancy of scheduling queues or the average number of acknowledgement signals (such as HARQ ACQ and NACK) can be included for forming the values for the current load states.

In addition the reported load information can also be used by the CRNC to give another network node SRNC (Serving RNC) a handover indication (HOI) for the purposes of optimizing load distribution in the radio communication system.

The background to this is as follows:
Each network node CRNC can become a Serving RNC (SRNC) for a specific user equipment, if this network node is the first to exercise specific checking functions over specific user equipment UE, since this user equipment UE is currently located in the area of this specific RNC. If the user equipment UE now moves and, in doing so, leaves the area of the SRNC and enters the area of another CRNC, the SRNC retains control over the user equipment UE and the new CRNC merely serves to forward the control actions of the SRNC. The new CRNC is therefore referred to as the Drift RNC (DRNC) for these control actions. Thus if resources are to be allocated for data connections for example to user equipment UE in such a case, the SRNC can no longer control this itself since the user equipment UE is in the area of a DRNC. The SRNC must then request the DRNC to release corresponding resources.

Two SRNCs are shown in FIG. 1 Let us assume that SRNC1 is responsible for controlling user equipment UE1 and SRNC2 for controlling user equipment UE2, UE3. The user equipment UE1, UE2, UE3 however is now located in the area of the CRNC also shown in Figure 1, which now acts as a DRNC for the user equipment UE1, UE2, UE3 and for the SRNC1 and SRNC2 and the administers the physical resources of the NodeBs assigned to it. The CRNC acting as DRNC can however, as a result of its knowledge of the load circumstances in the cells A, B, C, D or at NodeB 1 and NodeB 2, transfer recommendations to the SRNC1 and SRNC2 in each case such as Handover Indications (HOI) for example.

There is provision in HSDPA for the most recent handover decisions to be made by the corresponding SRNC. Basically handover decisions are made on the basis of the transmission quality for a radio connection to user equipment UE. The load-based handover decision here offers a further opportunity for optimizing the operation of a radio communication system and is of course also applicable in other types of hierarchical radio communication system. An additional option is thus created for making a radio connection (Serving Highspeed Downlink Shared Channel HS-DSCH Radio Link) from a first cell into a second cell.

Thus, in the example of FIG 1 the CRNC, on the basis of the transferred load information CLR of the base station NodeB 2, can send the SRNC2 a handover indication HOI on the basis of which a handover of the radio connection to the user equipment UE3 from cell C into cell D can take place, if in cell C the average usage of certain resources exceeds a defined threshold value. As a further requirement for the execution of such a handover there is usefully provision for this only to occur if, in the new cell, here in the

cell D, there are also adequate reception conditions for the terminal UE3. Furthermore the CRNC can also use the load information from the other device of the radio communication system known to it as a basis for rejecting or accepting the desired handover, if this serves to optimize the load situation in the radio communication system.

The following functionalities of the CRNC can also be especially supported by the invention:

- a dynamic adaptation of the allocated resources for a transmission of data packets with HSDPA, for example a reduction or increase in the number of codes (channelization codes) used for the transmission,
- Accepting or rejecting incoming packet data connections
- Accepting or rejecting a handover
- Transfer of handover recommendations to SRNCs for optimizing the load situation or using the physical resources in the cells administered by the CRNC.